STAR EMC REQUIREMENTS DOCUMENT

1. INTRODUCTION

The STAR detector, one of two large detector facilities at the Relativistic Heavy Ion Collider (RHIC) is being configured to play a leading role in the study Au+Au, p+Au and p+p collisions at center of mass energies up to 500 GeV/u for pp and nominally up to 200 GeV/u for AuAu. The STAR detector has been specifically designed to take advantage of the enormous range of physics opportunities provided by the Collider and its variety of projectiles, including polarized protons. An important sub-set of these physics opportunities ranging from the spin structure of the nucleon and nuclei, to the gluon structure function in heavy nuclei and color screening of heavy vector mesons in the quark gluon plasma, require that a large solid angle electromagnetic calorimeter complement the tracking and particle identification of the STAR TPC and related systems.

The purpose of the present document is to convey the design requirements of the STAR Electromagnetic Calorimeter and to justify those requirements in terms of their relation to the proposed physics program and realistic budgetary constraints. It is beyond the scope of the present document, however, to attempt to justify the proposed physics program. In the following, therefore, we will merely mention physics topics in passing where required and assume that the reader is knowledgeable concerning the significance of cited physics topics to the entire RHIC program.

2. EXECUTIVE SUMMARY

2.1 Summary Description:

The full STAR Electromagnetic Calorimeter (EMC) consists of 4 detectors; the Barrel Electromagnetic Calorimeter (BEMC), the Barrel Shower Maximum Detector (BSMD), the Endcap Electromagnetic Calorimeter (EEMC) and the Endcap Shower Maximum Detector (ESMD). In addition, there is a separate readout of the first layer of EMC, referred to as Preshower (BPRE and EPRE). (We loosely refer to the calorimeter parts as EMC and the overall system as EMC. In the present document, we are concerned primarily with the Barrel Calorimeter detectors

The EMCs towers are fast detectors providing digital data at every RHIC beam crossing. They are thus used in STAR's Level-0 triggering as well as higher levels. Participation in the level-0 trigger is fundamental as this is the only level in the STAR trigger system where event selection takes place. All other trigger levels merely reject events selected at level-0. Thus, through the EMC, STAR achieves trigger capability for direct photons, single- and di-electrons and, through their electromagnetic component, hadronic jets, total transverse energy, etc. Beyond triggering, of course, the EMC provides an essential component of STAR's physics observable list. In the heavy ion program, in particular, the observation of the total electromagnetic energy, for example, in large solid angle and its relation to other features of the event is unique to STAR.

The SMD's have many more channels and are slower than the EMC tower measurements, and hence are not included at their full complexity in the lowest level triggers. They provide finer spatial resolution for locating electrons and photons and sample the charged particle density at the location of the maximum of an electromagnetic shower, thereby providing important EM/Hadronic particle discrimination.

We assume a canonical 4800 channels for the barrel with detector towers 0.05 in η by 0.05 in ϕ and 4800 Preshower channels, also .05 by .05. We assume 720 channels in the Endcap with some towers 0.1 by 0.05 in η,ϕ and others 0.1 by 0.1, consistent with physics and construction. The Preshower is also utilized in the Endcap.

The BSMD has 36000 pads (strips) arranged in both the eta and phi directions. These are coupled to two independent sets of wires, which gives two, nearly independent, sampling of showers. The 18000 eta strips vary in size with the largest located at high eta. The average $\Delta\eta$ is about 0.007. These strips are 1.46 cm wide at low η and wider at high η. The phi strips are only 0.1 in length in the eta direction, in order to reduce the occupancy in AuAu collisions, and to allow pattern recognition in small 0.1 by 0.1 blocks in eta-phi.

The signals from the calorimeter phototubes (PMT's) are integrated and digitized with 10 bit resolution for the DAQ. The output of the ADC goes to digital pipelines, and then the fraction of the events selected by the trigger goes to token-addressable derandomizing buffer memory and from there to an EMC Data Collector.

In parallel with the data path to DAQ, the Front End Electronics is configured to provide a fast PMT trigger path with a reduced resolution. Trigger primatives of 6 bits for EMC patches of 0.2 by 0.2 in eta-phi are provided, as well as signals of 6 bits for the highest 0.05 by 0.05 tower within each 0.2 by 0.2 area. These are then processed in the EMC portion of Level 0 trigger to provide triggers for photons, jets, electrons, isospin ratios, etc.

The EMC allows:

- a trigger for electromagnetic signals in STAR.
- a fast, high resolution trigger for high P_T in STAR.
- Isospin triggers, using the ratio between the electromagnetic and charged hadronic energy
- Direct photon triggers, for measuring the gluon structure functions of nuclei and jet quenching in the quark-gluon plasma, which cannot be formed otherwise.
- High energy electron triggers for W's and Z's in the spin physics program and moderate energy electron and di-electron triggers for J/ψ in both the heavy ion and light ion programs
- Jet triggers for measurement of the gluon structure function and its spin content as well as jet quenching in a plasma

The signals from SMDs are amplified at the high eta end of the calorimeter stack and passed to a local switched capacitor array (SCA) which functions as an analog pipeline. On a level-0 accept, the SCA's are readout sequentially, passing their analog information to 10 bit ADC's located outside the magnet providing an 80:1 multiplexing ratio.

The EMC is a component of the overall STAR detector system. As such, the EMC observes all of STAR's existing interface standards and specifications for slow controls, trigger, on-line and DAQ.

2.2 Table of critical parameters

Parameters	BARREL		ENDCAP	
	BEMC	BSMD	EEMC	ESMD
Solid angle	76% of 4π	76% of 4π	10% of 4π ea.	10% of 4π ea.
Channel count				
Basic	4800	N/A	720	N/A
w/ preshower	9600	N/A	720	N/A
maximum	9600	36000	720	9000
No. of layers	21	1	24	1
Radiation Length	18	N/A	20	N/A
photo electron/mip/layer	2	N/A	2	2
PMT gain	4×10^5	N/A	4×10^5	1×10^6
Wire gain	N/A	3500	N/A	N/A
Signal length	40 ns	140 ns	40 ns	40 ns
90% chg. Dynamic range	10 bits	10 bits	10 bits	10 bits
Energy resolution	~16%/√E	12% + 86%/√E	~16%/√E	under study
Pixel size in cm	~10 cm	~1.5 cm x ~ 20 cm	<25 cm	~1.2 cm x ~ 30 cm
η strip size in (η,ϕ)	(0.05,0.05)	~(0.0066,0.1)	<(0.1,0.1)	~(0.007,0.2)
ϕ strip size in (η,ϕ)		~(0.1,0.0066)		~(0.2,0.007)
Occupancy				
Min. Bias	~1%	~1%	~2%	~1%
C+C	~6%	~1%		
Au+Au	50%	>5%	100%	>30%
Calibration	mips	charge injection	mips	charge injection
	Conversion electrons	Conv. electrons	Conversion electrons	Conv. electrons
	J/ψ (correlated pairs)		J/ψ (correlated pairs)	
	LED		LED	
Time resolution	<110 ns	<110 ns	<110 ns	<110 ns
Readout time to level 2	<250 u s	<250 u s	<250 u s	<250 u s
Event size				
Min. bias with sparsification	0.8 kB	1 kB	3 kB	1 kB
Min. bias without sparsification	19 kB	36 kB	6 kB	9 kB
High voltage				
Maximum	1700	1600	1700	1600
No. of channels	5100	>4	766	>2

3.0 DETECTOR REQUIREMENTS

3.1 SYSTEM FUNCTIONALITY

Requirement:

There shall be a sampling electromagnetic calorimeter in STAR with coverage of 2π in ϕ and -1 to +2 in η. Dead areas shall be minimized relative to the Moliere radius of an electromagnetic shower (~2cm) and to the size of a hadronic jet.

Justification:

A minimum acceptance of -1 to +2 in η is required to give adequate coverage for jets and photons to cover the relevant x range for measuring gluon distributions in p-Au and pp collisions. Also, jet reconstruction requires fiducial cuts far from edges, which would severely limit the acceptance for a smaller detector. Within this coverage, dead areas of the scale of the observable, electromagnetic or hadronic showers, have an unacceptable impact on the detectors acceptance since each dead area nominally requires a fiducial cut of comparable size.

3.1.1 Measurement Functionality

Requirement:

The EMC together with a SMD must enable measurements of the gluon structure function in nuclei needed to understand A+A collisions. In conjunction with RHIC's polarized proton beam, the EMC must enable the measurement of the spin dependence of the gluon densities of nucleons and nuclei. The EMC will enable the measurement of the Isospin ratio in the products of A+A collisions over solid angles of about 1 in η and ϕ or larger. Together with the TPC it will enable the finding and measurement of hadronic jets needed to understand both shadowing and quenching. Together with the TPC and a vertex position measurement similar to that from the SVT or beam location it will enable the finding and measurement of electrons from W and Z decays and other particles such as J/ψ for the study of hadronic charm production and color screening in the plasma.
The EMC must enable the detection and reconstruction of π^0's (and η's) above approximately 1.5 GeV (2.5 GeV/c) in the Au+Au environment to provide a direct link between the thermal region of the spectrum and the medium P_T region where jet quenching begins to dominate the spectral shape.

Justification:

These observables span the physics program envisioned for RHIC addressable with electromagnetic measurements both in conjunction with and without STAR's tracking detectors.

3.2 CALORIMETER CHARACTERISTICS

3.2.1 Energy Resolution

Requirement:

The electromagnetic energy resolution, defined as the Gaussian sigma divided by the mean, shall be better than required to satisfy the measurement functionality.

Justification:

The measurement functionality of section 3.1.1 is a requirement. Monte Carlo studies show that a resolution better than or equal to $20\%/\sqrt{(E[GeV])}$ at energies above 300 MeV satisfies the measurement functionality of section 3.1.1.

For example:

- In the measurement of the Isospin ratio in pion production over large solid angle by statistical averages in one event have shown that this resolution is adequate.
- At the high energy end, where we use the energy in the calorimeter vs. the momentum from the TPC to identify electrons, this energy resolution is better than the momentum resolution from TPC plus vertex.
- For direct-γ+jet studies to measure the gluon structure function, this resolution on the γ is better than the resolution possible for the jet.

3.2.2 Spatial Resolution

Requirement:

The Calorimeter tower size shall be small enough to reduce combinatorial problems (average occupancy <1) in resolving multiple γs in p+p and identifying photons and electrons in Au+Au events where the matching of the calorimeter tower and SMD signals is used. For cost reasons, we want the cell size as large as consistent with the physics.

Justification:

For one method of the Isospin ratio measurements in Au+Au events, we count the multiplicity by using an energy sum and average energy per π^0 or per charged pion, we do not care about multiple hits in single calorimeter cells and consequently do not require an average occupancy <1. For the principal method of Isospin ratio measurement however, we count the towers with zero hits, and an occupancy of about 50% is near optimum. A calorimeter segmentation of 0.05 x 0.05 gives about 50% occupancy in M.C. studies.

Identification of electrons in Au+Au events will be limited by background in the towers from hadrons and photons. The higher the average energy associated with this background the higher the minimum P_T at which electrons can be isolated. A calorimeter segmentation of 0.05 x 0.05 gives an acceptable background energy per tower in Monte Carlo studies.

3.2.3 Solid Angle Coverage

Requirement:

The device will subtend 2π in ϕ and -1 to +2 in η, with inactive regions that do not compromise the electromagnetic energy measurement or jet reconstruction capabilities..

Justification:

The required acceptance in ϕ for single jets and di-jets is documented in the EMC STAR upgrade proposal. The acceptance is essentially zero below a size (diameter) of 1.4 in η by 1.4 in ϕ. The acceptance has a sharp rise continuing to about 98 % to 100% coverage in ϕ.

The acceptance in η for γ+jet is documented in the RHIC SPIN proposal and STAR Note No. 77 by M. Beddo *et al.* The coverage of the gluon distribution in Bjorken-x for both p+A and p+p physics is enhanced dramatically by the Endcap EMC, covering rapidities from 1 to 2 in conjunction with the barrel coverage from -1 to +1.

A study of the effects of dead regions vs the size of these regions is documented in Star Notes for both EM showers and for Jets. It is shown that the effects are not too significant for the proposed construction.

3.3 SHOWER MAXIMUM DETECTOR

Requirement:

Electromagnetic showers must be precisely localized in space and their characteristic transverse size parameters must be measured. An independent energy measurement near shower maximum is also needed.

Justification:

In order to accomplish its measurement functionality goals, the EMC must measure photons and electrons, often in large hadronic backgrounds. An important component of our discrimination between electromagnetic and hadronic showers and our ability to discriminate photon pairs in a single tower will come will come from the characteristic transverse shower shape and dimensions at a point near the energy density maximum of an electromagnetic shower in the longitudinal direction. The observation of direct photons, whether in p+p or Au+Au, will rely in an essential way on the ability to identify and isolate photons in this manner. Furthermore, the construction of an invariant mass for photon pairs or di-electrons, particularly at high P_T, requires precise localization of the showers. An independent measurement of the energy in the EMC near the shower maximum depth will give a pion rejection of about a factor of 5 when triggering on electrons, according to M.C. studies

Status:

The combination of large EMC cell size and one layer of fine-grained detector (Shower Maximum Detector, SMD) at a few radiation lengths deep is the most economical way to do the required electromagnetic shower localization and characterization. It has been shown that this approach allows direct photon physics with acceptable error bars (e.g. CDF).

The SMD strip sizes and wire channel size can be made consistent with the size of electromagnetic showers at the depth of the SMD (about 5 X_0 depth, see below), and also consistent with separating the two γs from π^0 of at least 20 GeV (about 3 cm).

This type of detector has worked well in CDF for many years for direct photon studies with large calorimeter cells and the electronics at CDF is now being upgraded to work with a crossing time similar to the RHIC crossing period.

Detailed simulations have been conducted to study the optimum depth to place the SMD detector within the EMC. A compromise is required by the very broad energy range of photons and electrons encountered in the entire STAR physics program. A depth of $5X_0$ has been found has been found to provide the required γ / π^0 separation at the highest energies while providing good discrimination for the soft photons encountered in the heavy ion program and in asymmetric π^0 decay.

4 CALORIMETER ELECTRONICS

4.1 Signal Shaping for PMT Signals

Requirement:

The Phototube signals shall be integrated for sufficient time such the fluctuations in the remainder of the charge will effect the result by less than 1%.

Justification:

Integration of the signals should not degrade the calorimeter performance. Measurements done on the SDC prototype EMC in test beam showed that at least 40 ns was necessary in order to collect enough of the charge so that fluctuations in the remainder affect the results to less than the 1% level.

4.2 Dynamic Range of Calorimeter ADCs

Requirement:

The dynamic range of the calorimeter must adequate to measure soft π^o photons in the Au+Au and pp program and electrons from W's and Z's in the pp program.

Justification:

This energy scale comprises the full scope of the STAR physics program. The low energy end of the Physics range is specified by the need to measure the soft photon from π^0 background to direct γ events and to reconstruct low P_T π^o's in the Au+Au program. The high end of the range is fixed by electrons from W^-, W^+, and Z_0 decay, up to 60 GeV and direct γs up to 20 GeV.

4.3 EMC Pipeline

Requirement:

The EMC readout must be deadtimeless out to level zero time.

Justification:

The fast detectors in STAR are to be deadtimeless out to the level zero trigger time.

Status:

The data acquisition system throughout STAR must be deadtimeless for the fast detectors as long as tokens (See TRIGGER Requirements Document) are available. To accomplish these system goals, the EMC data from each phototube must be buffered on the detector in two ways: Data digitized from every crossing must be pipeline stored until level zero trigger time. At level zero trigger time those events passing the level zero criterion must be preserved for use in L1, L2, L3 etc. logic.

The deadtimeless requirement comes from the p-p and light ion physics program where the baseline RHIC collision rate can be as high as 10^6 per second, and the upgrade collision rate as high as 10^7 per sec. If a deadtime of as little as two crossings were incurred on every collision the system would have an unacceptable 20% inefficiency. For the Au-Au program, if a few microseconds deadtime were incurred for each level zero trigger a level zero trigger much tighter than minimum bias would be required to avoid an unacceptable level of inefficiency .

When a collision rate higher than the baseline p-p rate is achieved at some later date the need for deadtimeless data flow into level one will be all the more essential.

5.0 SMD ELECTRONICS

5.1 AMPLIFICATION AND SHAPING

Requirement:

The dynamic range of the Pre-amplifiers will be approximately 10 bits (see 5.2). The pre-amplifiers must be mounted on the EMC modules.

Justification:

The dynamic range is chosen to span from 1 mip to the shower maximum encountered in W's and Z's in pp running. The size of the raw signals is as small as 60 femto-Coulombs. The cables must be routed next to the magnet coils and the magnet induced noise from capacitive coupling to the SMD cables requires signal amplification on the detector and differential transmission off of the detector.

5.2 DYNAMIC RANGE OF SMDs

Requirement:

A dynamic range of about 600 is necessary (10 bits - linear).

Justification:

The range of signal pulse height is more than 120 to 1 and we need several bins of resolution at the low end to measure the signal. We need to see electromagnetic showers down to 0.5 GeV to reduce backgrounds to direct photons to an acceptable level. This means we need to see photons converting into very few electrons near the SMD. At the high end, we want to see electrons from W's and Z's at up to 60 GeV and photons above 20 GeV. We must limit saturation because we do fits of shower shape (pulse height vs. x) to eliminate π^0 from 2 close γ's. We also use pulse height to match x and y views .

5.3 SMD PIPELINE and TOKEN Addressable BUFFER

Requirement:

SMD data from each channel must be buffered on the detector in two ways. Analog data from every crossing must be stored at least until Level-0 trigger time. This is the Pipeline requirement.

Also, data associated with a Level-0 trigger must be buffered until it can be read out to Level 2 Trigger and DAQ Level-3 processing off-detector.

Justification:

We must handle bursts of events close in time without loss and also provide a high percentage of live time in order to do the physics. A pipeline and the STAR token system will accomplish this.

6.0 EMC TRIGGER

Introduction

In pp, pA, and AA collisions, the STAR EMC can be used to trigger on events applicable to the study of the gluon structure function, jet properties in heavy ion collisions (e.g. quenching), J/psi with di-electrons, isospin fluctuations, and high and medium pt physics with photons and jets. In polarized pp collisions, the EMC can be used to study the gluon spin structure of the nucleon by triggering on gammas, gamma plus jet, and jets, and the transversity structure function by triggering on Z's and jets. The quark and antiquark spin structure functions can be studied with W and Z production.

To trigger on these phenomena using the EMC, one must allow for selecting the following event types:

A. Jets for the study of the gluon structure function and the gluon spin structure function.

B. Direct γ for the study of the gluon structure function (p-Au) and gluon spin structure function in pp and jet quenching in Au-Au.

C. Electrons for the study of J/ ψ suppression, W±, Zo physics, heavy flavor studies via the semi-leptonic decays c -> e+X and b -> e+X in pp collisions. Electrons also allow, in situ, cross-calibration between TPC momentum and EMC energy via E/p

D. Et, the total transverse energy deposited in the EMC and its distribution, $d^2E_t/d\eta d\phi$ to improve STAR's centrality trigger by utilizing the neutral Et which would otherwise be missed and which comprises 30% of the emitted energy. Et is also part of the trigger for other high Et processes such as direct gamma plus jet, two jets and W's.

E. Abnormal isospin ratios for the study of disordered chiral condensates through fluctuations in charged to neutral energy ratio.

To accomplish these physics goals, the following requirements are established.:

6.1 Calorimeter Trigger Requirements:

6.1.1. Calibration Triggers

Requirement: Calibration triggers must be supplied for absolute calibration of the EMC using LED's and charge injection.

Justification: The EMC must be calibrated and the associated data must be passed to the DAQ.

6.1.2. Single tower

Requirement : Select events in which any single tower (.05 x .05) is above one of three programmable thresholds without introducing deadtime.

Justification: Selection of potential e/γ events via their signature of a highly localized energy deposition. The three thresholds allow for prescaling of the lower pt event triggers over a range of pt . The condition of no deadtime is required to optimize the maximum effective integrated luminosity. There will be information in the EMC towers for virtually every crossing.

6.1.3. 0.2x0.2 patch sums

Requirement : Select events in which at least one 16 tower sum (non-overlapping) is above programmable threshold without introducing deadtime.

Justification: This is an effective jet trigger and is also an intermediate quantity required for the overlapping jet trigger (see below). The sixteen tower sums will also account for electromagnetic showers that cross tower boundaries that would otherwise be lost. About 15% loss in EM good events will occur without this trigger.

The condition of no deadtime is required to optimize the maximum effective integrated luminosity. There will be information in the EMC towers for virtually every crossing.

Status: Calculation of these patches is presently included in the EMC Phototube card design as a 6 bit number.

6.1.4. 0.8x0.8 patch sums

Requirement : select events in which at least one 256 tower sum (overlapping) is above programmable thresholds.

Justification: Selection of potential jets via their signature of broad energy deposition over a region in ($\Delta\eta$,$\Delta\phi$) of (0.8, 0.8), comparable to the core a typical jet.

6.1.5. Global Et

Requirement : select events in which Global Et is above programmable thresholds without introducing deadtime.

Justification: Global Et in pp and p-A collisions will provide a way to trigger on jet-jet and γ-jet events via the energy deposition. In AA collisions this trigger will also give a measure of the centrality or hardness of the collision. The condition of no deadtime is required to optimize the maximum effective integrated luminosity.

6.1.6. Isospin Patches

Requirement : Select events in which ECAL / E CTB in at least one of the approximately 12 (η,ϕ) patches is above a programmable thresholds without introducing deadtime. Patches are fixed in (η,ϕ) space with size $(\Delta\eta,\Delta\phi)$ = (0.8 x 0.8) to (1. X 1.).

Justification: Selection of events with anomalous isospin by comparing calorimeter patches with similar (η,ϕ) patches in the CTB which are sensitive to charged particles. Simulations have shown that this patch size appears to be the best match to both expected physics and statistical significance. Allowing for two thresholds will permit pre scaling over selected energy ranges. The condition of no deadtime is required to optimize the maximum effective integrated luminosity.

6.1.7. Luminosity monitor

Requirement: Scaled trigger values will be generated corresponding to a luminosity measurement.

Justification: The luminosity of events associated with the EMC must be measured, especially for polarized pp running to reduce relative luminosity errors to near 10^{-4} in spin physics studies.

Status: Proposed monitors under study inclue Et above two thresholds, Multiplicity in the CTB above three thresholds, and combined MWC and CTB multiplicity.

6.1.8. Electrons and gammas

Requirement : Select events in which a localized energy cluster is above some programmable threshold and isolated, that is, the sum of neighboring towers is less than some programmable threshold.

Justification: Allows for selection of events having at least one e or γ. Background events will be due to jets with non-isolated energy distributions.

6.1.9. Jets

Requirement : Select events in which at least one multiple tower / cone is above one of several programmable thresholds. Prescale triggering on lower thresholds but not highest threshold.

Justification: Allows for selection of events having at least one jet. Jets are the foundation of all high pt physics. In pp and pA jets will be used to study the gluon structure function.

6.1.10. Correlated multiple towers

Requirement: Select events with two towers, a tower-patch or a patch-patch above programable thresholds and within a programmable spatial constraint. Such events would include di-electrons for example.

Justification: Allows for the selection of events used in the study of events involving J/ψ's (e-e) jet-jet and gamma-jet.

6.2 SMD Trigger Requirements

6.2.1 SMD Summary Information

Requirement: In the design and implementation of the EMC, an upgrade path shall be maintained which permits transmission of SMD summary information to level-0 from patches of approximately 2% of the EMC's acceptance.

Justification: At such time as upgraded pp luminosity is available, SMD summary information may be required in level-0 to achieve desired trigger rates.

Status: A possible upgrade for higth luminosity operation in which SMD wires are ganged together creating patches of 0.1x1.0 in eta-phi is easily retained.

6.2.2 SMD in higher level triggers

Requirement: In the design and implementation of the EMC, an upgrade path shall be maintained which permits transmission of full resolution SMD information to level-2 from the full EMC's acceptance in a time less than 250 microseconds.

Justification: At such time as upgraded pp luminosity is available, full SMD information may be required in level-2 to achieve desired trigger rates.

Status: An additional fiber array (in parallel with those transmitting EMC data to level-3) to a dedicated level-2 memory and processor farm would accomplish this.

6.3 FAST IMPLEMENTATION

Requirement:

The trigger rate must be reduced at each level of trigger in order to allow more detailed processing at higher levels which is in turn needed to match the bandwidth to tape with acceptable livetime.

Of the triggers described above in sections 6.1 and 6.2, the following must be implemented in the shortest possible time (level-0) to accomplish this:

trigger requirement 6.1.2 -- single towers

trigger requirement 6.1.3 -- 0.2x0.2 patch sums

trigger requirement 6.1.5 – global Et

trigger requirement 6.1.6 – isospin patches

Justification:

These four triggers will efficiently pass all event types discussed in section 6.0 on to higher level processing at acceptable trigger rates.

6.4 LEVEL - 0 SUMMARY DATA

Requirement:

As much Level 0 EMC trigger primitive data as practical will go into the Final Data in each event.

Justification:

It will be used to debug the trigger by comparing its data with calculations on the data read-out from the EMC as processed by software trigger simulations.

6.5 MAXIMUM RATES

6.5.1 TPC related events

Requirement:

The maximum average rates into Level 3 from EMC associated with TPC and the rest of the STAR detector shall be no more than 60 Hz.

Justification:

Monte Carlo Studies of high luminosity pp reactions have indicated that the above rates will allow the physics to be done with at least 50% live time. Such rates will be achieved with trigger thresholds which also allow the physics to be done.

6.5.2 EMC/CTB events

Requirement

Maximum average rates to Tape from EMC in association with CTB will not exceed 1kHz.

Justification:

Monte Carlo Studies of luminosity AuAu reactions have indicated that the above rates will allow an efficient and careful study of trigger thresholds in the regime of rare events in multiplicity/transverse energy space. Event characteristics in this space are suggested to be directly related to the QGP phase transition.

6.6 INPUT TO STAR LEVEL 2

Requirement:

The EMC shall maintain an upgrade path to put the full resolution, pedestal-subtracted EMC Phototube data and Shower Max data for events accepted by Level 1 into a memory for use by Level 2.

Justification:

Level 2 may need the EMC data for calculation.

6.7 DATA PIPELINES

Requirement:

The length of the EMC pipelines on the detector that hold data from every crossing until Level 0 trigger must be of programmable length.

Justification:

The time of level 0 may be made later to accommodate different physics calculations in level 0.

6.8 LATENCY

Requirement:

In the event that the upgrade is exercised to place full resolution EMC and SMD data to level 2, it shall be accomplished in 250 micro seconds or less.

Justification:

The maximum transfer time must be as short as possible to allow level 2 processing time..

6.9 INPUT TO STAR DAQ

Requirement:

Upon a Level 2 accept, EMC shall supply the full EMC data set to each of the 24 TPC Sector Crates for correlation with TPC tracks and/or passing to DAQ . In day 1 implementation it is sufficient that the data be passed to a single TPC sector crate.

Justification:

The data path for EMC to DAQ is through the sector crates. One sector crate can pass all the data, however, the amount of processing to do the correlation with tracks is large and can best be handled by multiple processors operating on independent parts of the TPC data.

7.0 SLOW CONTROLS

7.1 SLOW CONTROLS CONNECTION TO DETECTOR

Requirement:

There are slow controls inputs to EMC for the following functions:

- HV settings to Cockroft-Walton PMT bases
- Gas flow monitor for the SMD
- Calibration
    - LED pulse control (trigger setup, timing, amplitude, pattern)
    - Charge injection to SMD
    - Charge injection to PMT electronics
    - Forcing one range of dual-range ADCs
- Monte-Carlo event downloading
- Trigger threshold programming on EMC cards
- Initialization of system
    - Empty pipelines at startup
    - Load offsets to RHIC clock
    - Fiber driver initialization
- Read temperatures of PMT and electronics
- Monitor crate voltages
- Trigger threshold programming
-

Justification:

These functions are needed for routine operation.

7.2 SLOW CONTROLS CONNECTION TO PLATFORM

Requirement:

There are slow controls inputs to the electronics on the cart for the following functions:

- Pedestal downloading
- Begin run functions
- Buffer clearing
- Monte-Carlo event downloading
- Bad channel list download to EMC Trigger and Data Collector
- Run Header information download to Data Collector
- Bad channel list downloading for Level-1 or 2 (if this option is exercised)

Justification:

These functions are needed for routine functions implemented on the platform.